

## General Description

The Digital Blocks DB9000AXI4 TFT LCD Controller IP Core interfaces a microprocessor and frame buffer memory via the AMBA 4.0 AXI4 Protocol Interconnect to a TFT LCD panel. The DB9000AXI4 contains a selectable 256 / 128 / 64 / 32-bit AXI4 Master Interface and uses the AXI4 higher burst lengths & Quality of Service (QoS) capabilities to target higher resolution, higher color depth TFT LCD panels, with their resulting high frame buffer memory data bandwidth & bounded latency requirements.

The DB9000AXI4 IP Core can be implemented in an ASIC, ASSP, or FPGA device with an embedded microprocessor, an AMBA AXI4 Interconnect fabric, and SDRAM Controller for access to frame buffer memory. Typically, the microprocessor is an ARC, ARM, Intel, MIPS, OpenSPARC, PowerPC, or Tensilica processor and frame buffer memory is off-chip DDR / DDR2 / DDR3 SDRAM.

Figure 1 depicts the system view of the DB9000AXI4 TFT LCD Controller IP Core embedded within an integrated circuit device.

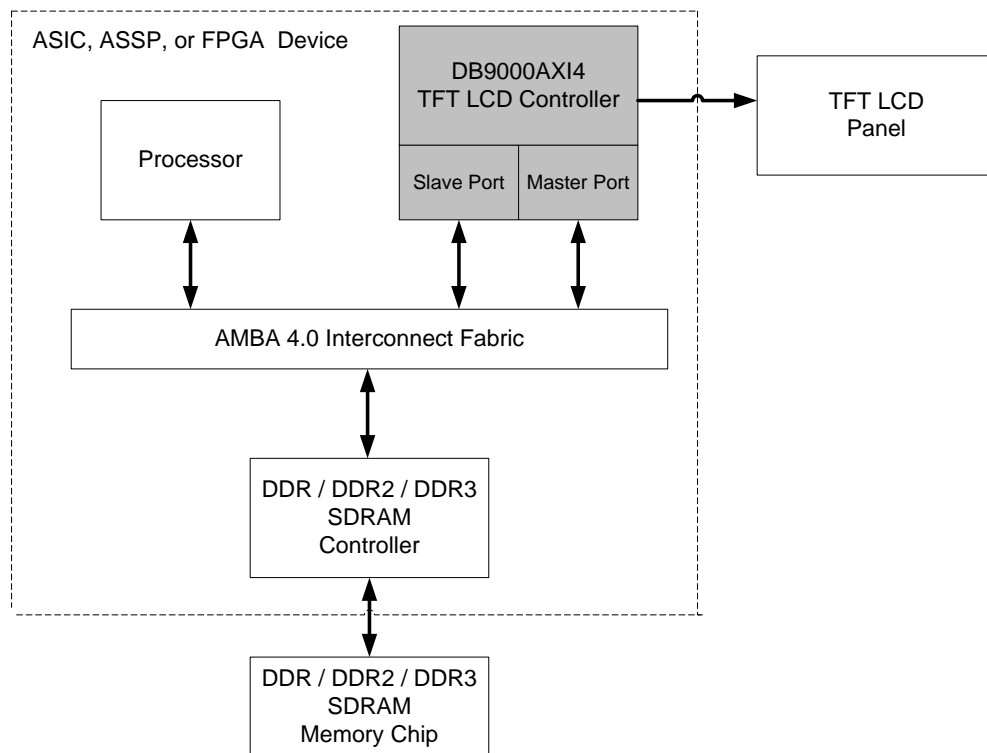


Figure 1: DB9000AXI4 TFT LCD Controller – System Diagram

## Features

- High-Resolution TFT LCD Panel support features by AXI4 Protocol:
  - Up to 16 overlap outstanding reads requests to the SDRAM Controller
  - Quality of Service (QoS) Support
  - Programmable burst lengths up to 256 beats
  - Wide AXI4 Master Port data width, up to 256-bits
- Wide range of programmable LCD Panel resolutions:
  - Maximum programmable resolutions of 4096x4096
  - Horizontal pixel resolutions from 16 to 4096 pixels in 16 pixel increments.
- Example LCD Panel high resolutions:
  - Digital Cinema Systems (DCI) 2048 x 1080 2K image, 4096 x 2160 4K image, & Cinema Scope HD 2560 x 1080
  - 4096x2560, 3840x2160, 2560x2048, 2048x2048, 2048x1536, 1920x1200, 1920x1080, 1680x1050, 1600x1200
  - 1600x900, 1440x900, 1366x768, 1280x1024, 1280x768, 1080x1920, 1024x768, 1024x600, 1024x576, 960x540, 800x600, 800x480
- Example LCD Panel medium / small resolutions:
  - 640x480, 640x400, 640x240, 640x200, 480x800, 480x640, 480x272
  - 480x234, 240x400, 240x320, 240x240, 320x200, 320x240
- Programmable 1 Port or 2 Port TFT LCD Panel interfaces
- Interface for 1 Port TFT LCD Panel:
  - 18-bit digital (6-bits/color) LVDS / CMOS
  - 24-bit digital (8 bits/color) LVDS / CMOS
- Interface for 2 Port LVDS TFT LCD Panel:
  - Two 24-bit digital (8 bits/color) LVDS / CMOS ports
- Interface to LVDS, DVI, HDMI, & DisplayPort Transmitters / Receivers
- Programmable frame buffer bits-per-pixel (bpp) color depths:
  - 1, 2, 4, 8 bpp mapped through Color Palette to 18-bit LCD pixel
  - 16, 18, bpp directly drive 18-bit LCD pixel
  - 24 bpp directly drive 24-bit LCD pixel
- Color Palette RAM to reduce Frame Buffer memory storage requirements and AXI4 Bus bandwidth (for lower color applications):
  - 256 entry by 16-bit RAM, implemented as 128 entry by 32-bits
  - Loaded via the Slave Bus Interface statically by the microprocessor or the Master Bus Interface dynamically with each frame by the DMA controller
- Programmable Output format support:
  - RGB 6:6:6 or 5:6:5 or 5:5:5 on 18-bit digital interface
  - RGB 8:8:8 on 24-bit digital interface

- Programmable horizontal timing parameters:
  - horizontal front porch, back porch, sync width, pixels-per-line
  - horizontal sync polarity
- Programmable vertical timing parameters:
  - vertical front porch, back porch, sync width, lines-per-panel
  - vertical sync polarity
- Programmable pixel clock:
  - pixel clock divider from 1 to 128 of Bus Clock
  - pixel clock polarity
- Programmable Data Enable timing signal:
  - Derived from horizontal and vertical timing parameters
  - display enable polarity
- AMBA AXI4 Interconnect:
  - Selectable 256 / 128 / 64 / 32-bit AXI4 Master Port for DB9000AXI4 DMA access of frame buffer memory for driving the display
  - Selectable 256 / 128 / 64 / 32-bit AXI4 or 64 / 32-bit AXI4-Lite Slave Port for control & status interface to microprocessor
- Three memories:
  - 32-word x 64 bit input FIFO, decoupling AXI4 bus & LCD panel clock rates. Integrated with DMA controller.
  - 256-word x 16-bit Color Palette RAM
  - 16-word output FIFO
  - FIFOs parameterizable in depth and width
- Power up and down sequencing support
- 9 sources of internal interrupts with masking control
- Little-endian, big-endian, or Windows CE mode
- AXI4 Bus - Designed to AMBA AXI Protocol Specification (V2.0)
- Fully-synchronous, synthesizable Verilog RTL core, with rising-edge clocking, No gated clocks, and No internal tri-states.

**Block Diagram**

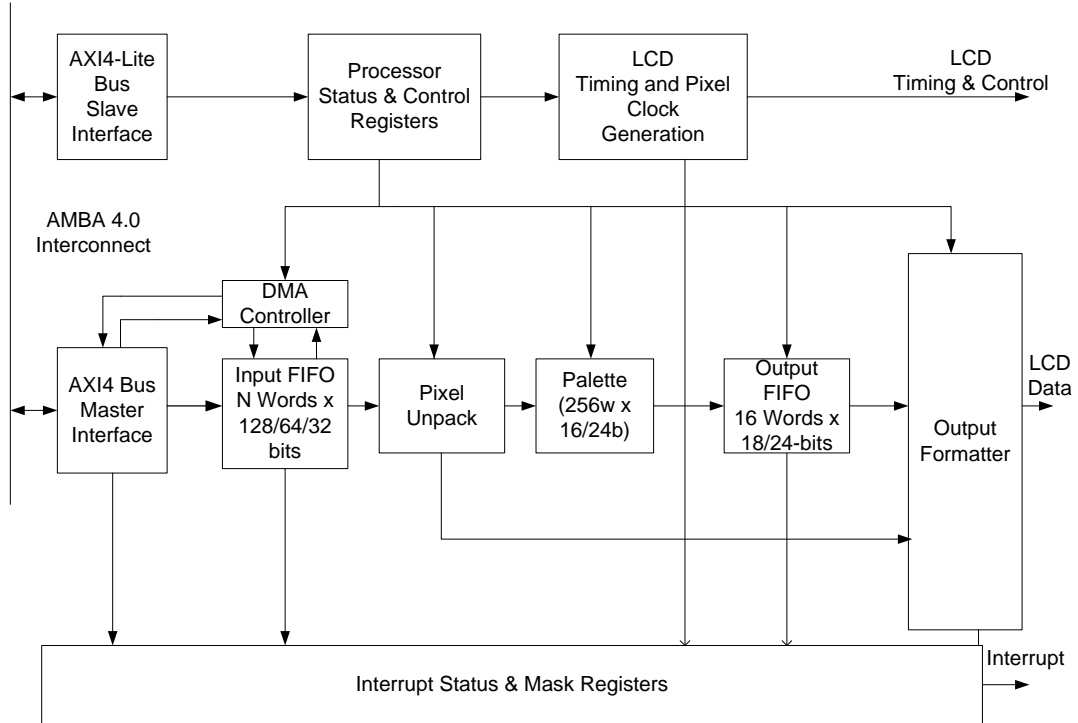


Figure 2: DB9000AXI4 AMBA Interconnect TFT LCD Controller

## Pin Description

The DB9000AXI4 contains three interfaces:

- LCD Panel Interface
- AMBA 4.0 Interconnect AXI4 Master Interface
- AMBA 4.0 Interconnect AXI4 Slave Interface (optional full AXI4 or AXI4-Lite)

The LCD panel and AXI4 Master Interface Tables 1, 2 respectively.

Name	I/O Type	Description
<b>LCD Panel Interface – Port 1</b>		
<b>LCD_PCLK</b>	Output	Pixel Clock
<b>LCD_HSYNC</b>	Output	Horizontal Sync Pulse
<b>LCD_VSYNC</b>	Output	Vertical Sync Pulse
<b>LCD_DE</b>	Output	Display Enable
<b>LCD_PE</b>	Output	Power Enable
<b>LCD_R[7:0]</b>	Output	Red Data
<b>LCD_G[7:0]</b>	Output	Green Data
<b>LCD_B[7:0]</b>	Output	Blue Data
<b>LCD Panel Interface – Port 2</b>		
Note: Optional Port 2 shares the common control signals with Port 1:		
<ul style="list-style-type: none"> <li>• <b>LCD_PCLK</b></li> <li>• <b>LCD_HSYNC</b></li> <li>• <b>LCD_VSYNC</b></li> <li>• <b>LCD_DE</b></li> <li>• <b>LCD_PE</b></li> </ul>		
<b>LCD_R_2[7:0]</b>	Output	Red Data
<b>LCD_G_2[7:0]</b>	Output	Green Data
<b>LCD_B_2[7:0]</b>	Output	Blue Data

**Table 1: DB9000AXI4 – I/O Pin Description for Interface to LCD Panel**

Name	I/O	Description
<b>AXI4 Global Signals</b>		
<b>ARESETn</b>	I	<b>Reset</b> – Active LOW Reset for AXI Master and DB9000 core.
<b>ACLK</b>	I	<b>Bus Clock</b> – Clock for AXI Master and one of two programmable clock sources generating PCLK. All AXI Master logic, including DMA Controller and ingress part of Input FIFO triggered on ACLK rising edge.
<b>AXI4 Read Address Channel Signals</b>		
<b>ARID[3:0]</b>	O	<b>Read Address ID</b>
<b>ARADDR[31:0]</b>	O	<b>Read Address Bus</b> - Address bus to the AXI4 Bus for reading of Frame Buffer Memory.
<b>ARLEN[3:0]</b>	O	<b>Burst Length</b> – Indicates number of word transfers in a burst. DB9000 AXI4 Master supports 1, 4, 8, 16 word transfers.
<b>ARSIZE[2:0]</b>	O	<b>Transfer Size</b> – Indicates the size of the transfer. DB9000 supports only word (8bytes/64-bit) transfer sizes.
<b>ARBURST[1:0]</b>	O	<b>Burst Type</b> – Burst Type, coupled with size information, details how address for each transfer within burst is calculated. DB9000 supports only burst type INCR – Incrementing Burst Type.
<b>ARLOCKM</b>	-	<b>Locked Type</b> – Unused by DB9000.
<b>ARCACHE[3:0]</b>	-	<b>Cache Type</b> – Unused by DB9000.
<b>ARPROT[2:0]</b>	-	<b>Protection Type</b> – Unused by DB9000.
<b>ARVALID</b>	O	<b>Read Address Valid</b> – When asserted HIGH indicates read address and control information valid on AXI4 bus.
<b>ARREADY</b>	I	<b>Read Address Ready</b> – When HIGH indicates Slave ready to accept address and associated control information.
<b>AXI4 Read Data Channel Signals</b>		
<b>RID[3:0]</b>	I	<b>Read ID Tag</b>
<b>RDATA[63:0]</b>	I	<b>Read Data Bus</b> - Contains read data from Frame Buffer Memory.
<b>RRESP[1:0]</b>	I	<b>Read Response</b> – Provides additional information on the status of a transfer.
<b>RLAST</b>	I	<b>Read Last</b> – Indicates the last transfer in a read burst.
<b>RVALID</b>	I	<b>Read Valid</b> – HIGH indicates required read data available and DB9000 can accept the data word.
<b>RREADY</b>	O	<b>Read Ready</b> – HIGH indicates the DB9000 can accept read data and response information.

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Table 2: DB9000AXI4 – I/O Pin Description for Interface to AXI4 Master Bus

## **Verification Method**

The DB9000AXI4 contains a simulation test suite with AXI4 Bus functional models that program the DB9000AXI4 control & status registers via the AXI4 Slave or AXI4-Lite Bus, generates frame buffer data in response to AXI4 Master requests, and checks expected results.

## **Customer Evaluation**

Digital Blocks offers a variety of methods for prospective customers to evaluate the DB9000AXI4. Please contact Digital Blocks for additional information.

## **Deliverables**

The DB9000AXI4 is available in synthesizable RTL Verilog, along with a simulation test bench with expected results, datasheet, and user manual.

## **Ordering Information**

Please contact Digital Blocks for additional technical, pricing, evaluation, and support information.

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